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Evaluation of Tether Anchor Zones for FMVSS No. 225

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16. Abstract

Federal Motor Vehicle Safety Standard (FMVSS) No. 225, Child restraint anchorage systems, requires that nearly all motor vehicles be equipped with Lower Anchors and Tethers for Children (LATCH). Tether anchors are located rearward from the child restraint system (CRS), often found on the back of the vehicle seat or rear package shelf. A Notice of Proposed Rulemaking (NPRM) was released in January 2015 that proposed a vehicle clearance criterion that would allow proper tightening of the child restraint tether strap. This criterion was to place the tether anchor 165 millimeters behind or below the head restraint. The distance from the seat back point to the tether anchor, defined as the tether distance measurement in this report, was based on common, reasonable lengths of non-adjustable tether hardware elements on child restraints. In response to questions about comments on the proposed vehicle clearance criterion of 165 millimeters, University of Michigan Transportation Research Institute (UMTRI) developed an alternate reference zone; the alternate reference zone would be set using the H-point and the R-point. The tether anchor would need to fall outside a 325-millimeter circle centered on the R-point that is truncated along the lower edge at 230 millimeters. The results of a survey of vehicles showed all the tether anchor positions measured were within the current FMVSS No. 225 zone. Nine of the 11 positions passed by being outside the UMTRI alternate 325-millimeter zone. Five of the 11 positions surveyed passed the NPRM-proposed tether distance by having a measurement greater than 165 millimeters. For every vehicle measured, excluding the pickup truck, there was sufficient space to relocate the tether anchor to meet the proposed tether distance requirement although redesign or reinforcement of the tether anchor may be needed because of unknown structural components in the space available.

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Executive Summary

Federal Motor Vehicle Safety Standard (FMVSS) No. 225, Child restraint anchorage systems, requires that nearly all motor vehicles be equipped with Lower Anchors and Tethers for Children (LATCH). LATCH anchors are a standard method of installing child restraint systems (CRSs) independent of vehicle seat belts. LATCH consists of two lower anchors and a top tether anchor. Each lower anchor is a 6-millimeter diameter rod located near the vehicle seat bight. Tether anchors are located rearward from the CRS, often found on the back of the vehicle seat or rear package shelf. The intent of the LATCH requirements was to make it easier to install CRSs and reduce installation errors so that their full effectiveness can be realized.

A Notice of Proposed Rulemaking[1] (NPRM) was released in January 2015 that proposed a vehicle clearance criterion that would allow proper tightening of the child restraint tether strap. This criterion was to place the tether anchor 165 millimeters behind or below the head restraint. A reference point, called the seat back (SB) point, is the location on the rear of the head restraint/seat back from which distance to the tether anchor is measured. The SB point is located "at the intersection of the plane parallel to the torso line reference plane that passes through the rearmost point of the seat and wrap-around line from the V-point to the tether anchorage." The distance requirement proposed from the SB point to tether anchor, defined as the tether distance measurement in this report, was based on common, reasonable lengths of non-adjustable tether hardware elements on child restraints.

In response to the NPRM, some manufacturers commented that there are often speakers located where the tether anchor would need to be placed, or that the tether anchor would be too close to the rear glazing to be usable, among other things.

In response to questions about comments on the proposed vehicle clearance criterion of 165 millimeters between the back of the head restraint and the vehicle tether anchor, University of Michigan Transportation Research Institute (UMTRI) developed an alternate reference zone; the alternate reference zone would be set using the H-point (represents hip point) and the R-point (represents shoulder point). The tether anchor would need to fall outside a 325-millimeter circle centered on the R-point that is truncated along the lower edge at 230 millimeters to maintain harmonization with the Australian Design Rule and the Insurance Institute for Highway Safety (IIHS) criteria.

To evaluate UMTRI's alternate reference point design, NHTSA's Vehicle Research and Test Center (VRTC) evaluated the current FMVSS No. 225 zone, the NPRM-proposed tether distance, and the UMTRI alternate 325-millimeter zone. In addition, this study also looked at the lengths of the child restraint tether hardware to validate the 165-millimeter length proposed in the NPRM.

The results showed all the tether anchor positions surveyed were within the current FMVSS No. 225 zone. Nine of the 11 positions passed by being outside the UMTRI alternate 325-millimeter zone. Five of the 11 positions surveyed passed the NPRM-proposed tether distance by having a measurement greater than 165 millimeters. For every vehicle measured, excluding the pickup truck, there was sufficient space to relocate the tether anchor to meet the proposed tether distance measurement requirement, although it may be necessary to redesign or reinforce the tether anchor because of unknown structural components in the space available. Also, the space needed

[1] 80 FR 3744, Docket No. NHTSA-2014-0123-0001.

behind the seat back to locate the tether anchor is usually smaller for the UMTRI alternate 325-millimeter zone than the proposed tether distance measurement for rear deck mounted tether anchors. A survey of CRSs showed that 16 of 20 tether anchor hardware measured less than or equal to 165 millimeters in length. CRS installation in two different vehicles with tether anchors that met the UMTRI alternate 325-millimeter zone allowed proper installation of CRS with a tether hardware length of 165 millimeters. However, vehicle seating positions with tether anchor locations that do not meet the proposed tether distance measurement requirement also allowed proper installation of the CRS. Nevertheless, it was observed that ease of installation can be improved with vehicle owner's instructions and not just measurement requirements.

1. Introduction

Federal Motor Vehicle Safety Standard No. 225, Child restraint anchorage systems, requires that nearly all motor vehicles be equipped with Lower Anchors and Tethers for Children. LATCH anchors are a standard method of installing child restraint systems (CRSs) independent of vehicle seat belts. LATCH consists of two lower anchors and a top tether anchor. Each lower anchor is a 6-millimeter diameter rod located near the vehicle seat bight. Tether anchors are located rearward from the CRS, often found on the back of the vehicle seat or rear package shelf. The intent of the LATCH requirements was to make it easier to install CRSs and reduce installation errors so that their full effectiveness can be realized.

A Notice of Proposed Rulemaking was released in January 2015 that proposed a vehicle clearance criterion that would allow proper tightening of the child restraint tether strap.[2] This criterion was to place the tether anchor 165 millimeters behind or below the head restraint. A reference point, called the seat back point, is the location on the rear of the seat back/head restraint from which distance to the tether anchor is measured. The SB point is located "at the intersection of the plane parallel to the torso line reference plane that passes through the rearmost point of the seat and wrap-around line from the V-point to the tether anchorage." The distance from the SB point to tether anchor, defined as the tether distance measurement in this report, was based on common, reasonable lengths of non-adjustable tether hardware elements on child restraints.

In response to the NPRM, some manufacturers commented that there are often speakers located where the tether anchor would need to be placed, or that the tether anchor would be too close to the rear glazing to be usable, among other things.

In response to questions about comments on the proposed vehicle clearance criterion of 165 millimeters between the back of the head restraint and the vehicle tether anchor, University of Michigan Transportation Research Institute conducted a project to estimate how many vehicles already meet this criterion, document physical features that prevent compliance, determine an alternative criterion that is more repeatable to measure, and check for conflicts between a new criterion and other regulations or practices.[3]

During this project, UMTRI developed an alternate reference zone; details on how they created this zone can be found in the report, *Investigation of Clearance Criterion Between Tether Anchor and Head Restraint* from January 2016. The alternate reference zone would be set using the H-point (represents hip point) and the R-Point (represents shoulder point). The tether anchor would need to fall outside a 325-millimeter circle centered on the R-point that is truncated along the lower edge at 230 millimeters to maintain harmonization with the Australian Design Rule[4] and the Insurance Institute for Highway Safety (IIHS) criteria.[5] Figure 1 shows the developed zone around the alternate reference point.

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[2] 80 FR 3744; Docket No. NHTSA-2014-0123-0001, www.regulations.gov/document?D=NHTSA-2014-0123-0001.

[3] Klinich, K. D., Boyle, K., Orton, N. R., Manary, M. A., & Ebert, S. (2016, January). Investigation of clearance criterion between tether anchor and head restraint (Report No. UMTRI-2016-4). Ann Arbor: University of Michigan Transportation Research Institute.

[4] ADR 34/02, www.legislation.gov.au/Details/F2017C00986.

[5] IIHS evaluates the tether anchor as to whether the anchor is on the rear deck or top 85 percent of the seat back, www.iihs.org/iihs/ratings/ratings-info/LATCH-evaluation.

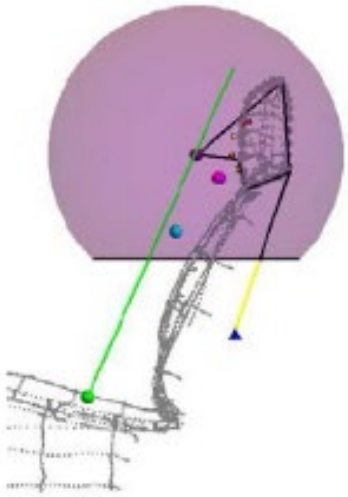

Figure 1. Example of UMTRI alternate reference point zone

1.1 **Objectives**

To evaluate UMTRI's alternate reference point design, NHTSA's Vehicle Research and Test Center evaluated the current FMVSS No. 225 zone, the NPRM-proposed tether distance measurement, and the UMTRI alternate 325-millimeter zone. In addition, this study also looked at the lengths of the child restraint tether hardware to validate the 165-millimeter length proposed in the NPRM.

Specific objectives of this study were:

1. Survey vehicles with different tether anchor locations.
    a. Verify the tether anchor was located within the current FMVSS No. 225 zone.
    b. Quantify the location of the tether anchors in relationship to the UMTRI alternate 325-millimeter zone.
    c. Measure and document the NPRM-proposed tether distance for each vehicle.
2. Directly compare the three measurements/zones of the tether anchor location in each vehicle.
3. Document whether space was available to relocate the tether anchor.
4. Survey the tether straps of various child restraints to verify CRS tether hardware in the market.

2. Vehicle Survey

VRTC measured six in-house vehicles with various tether anchor mounting locations. The vehicles were measured in the rear driver side position (RDP) and rear center position (RCP). Figure 2 shows an example of the positions recorded.

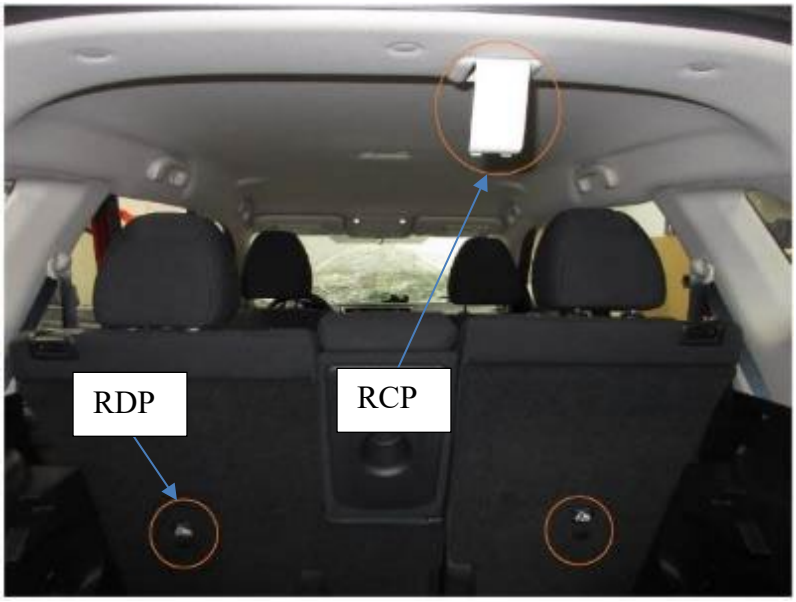

Figure 2. Example tether anchor locations

The following vehicles were selected for the survey.

1. 2010 Ford Taurus – Rear deck mounted anchor
2. 2011 Cadillac CTS – Rear deck mounted anchor
3. 2016 Toyota Sienna – Seat base mounted anchor
4. 2011 Hyundai Sonata – Rear deck mounted anchor
5. 2016 Chevrolet Tahoe – Seat back mounted anchor
6. 2016 Nissan Rogue – Seat back and roof mounted anchor

A passenger truck was also measured to better understand how the measurements/zones might work in a challenging environment; a 2016 Chevrolet Silverado was selected as the pickup truck evaluated.

2.1 Measurement Process

The FMVSS No. 225 test procedure specifies the use of a SAE-J826[6] 2D H-point manikin. Because VRTC does not have access to a 2D manikin, all recorded measurements were completed using the SAE-J826 3D manikin. Each vehicle was measured using a coordinate measurement machine (Faro Arm) and a flexible tape measure to collect the tether distance measurement. This differs from the measurement proposed in the NPRM of "the intersection of the plane parallel to the torso line reference plane that passes through the rearmost point of the seat and wrap-around line from the V-point to the tether anchorage." Rather, for simplicity, the measurement was considered the wrap-around distance from the tether anchor to the rearmost part of the seat or head restraint. It was noted that in vehicle environments using tether routers, the tether distance measurement was recorded most accurately using the flexible tape to quantify the wrap-around distance. The Faro Arm data collected from the manikin seating was then imported into CAD software (AutoCAD) and used to create an overlay plot comparing the different tether anchor criteria. An example plot is shown in Figure 3. Appendix C details the measurement procedure followed for each vehicle.

The plot contains the information to compare the three measurements/zones. The plot shows the current FMVSS No. 225 zone (dotted area) which is created from the H-point, the torso (back) angle, the vehicle's floor pan, and a 30-degree angle from the XY-plane passing through the R-point. The dotted area shows the zone the tether anchor must be within to meet the current FMVSS No. 225 regulation. The UMTRI alternate 325-millimeter zone (purple) is also created using the H-point, torso angle, and R-point; the 325-millimeter zone is created around the R-point and is truncated along the lower edge at 230 millimeters. For the UMTRI alternate zone, the tether anchor should be outside of the purple shaded area. Finally, the plot shows the tether distance measurement (in red) which was collected using the flexible tape measure from the rear of the seat to the tether anchor. The blue dimension approximates where the 165-millimeter tether location would be if relocated.

As a sample interpretation of the plot, the following example shows that the tether anchor in this vehicle passed the current FMVSS No. 225 zone since it is within the dotted area. It would have passed the UMTRI 325-millimeter alternate zone since it is outside the purple area. However, it would have failed the tether distance measurement because it is less than the 165-millimeter minimum dimension. Although there is space available to relocate the tether anchor to 165 millimeters, as indicated in blue, it may be necessary to redesign or reinforce the tether anchor because of unknown structural components in the space available.

[6] SAE International. (2015, November 10). [Standard No.] J826_201511, Devices for Use in Defining and Measuring Vehicle Seating Accommodation. Warrendale, PA: Author. Available at www.sae.org/standards/content/j826_201511/.

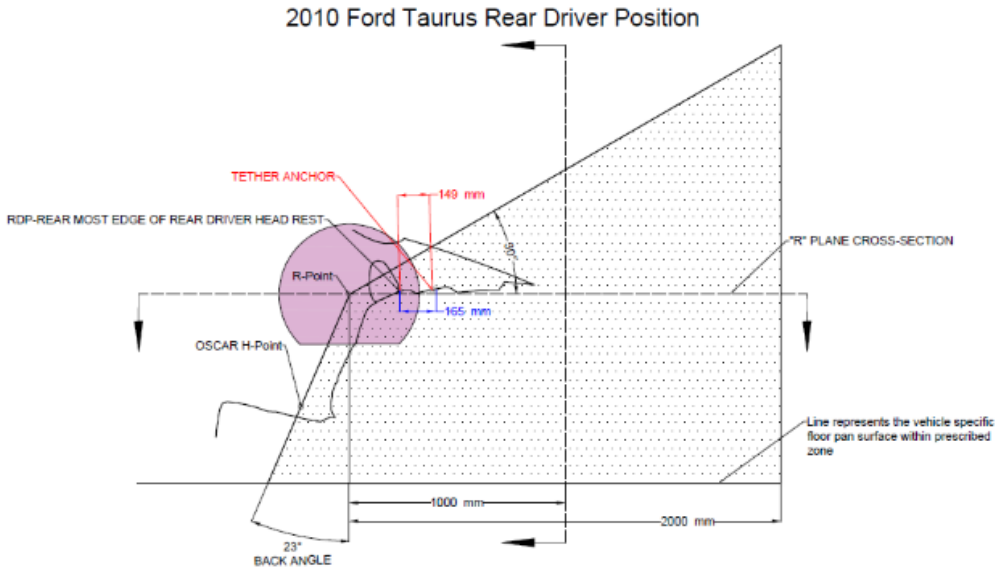

Figure 3. Example plot of zone comparisons for a seating position

The tether distance measurement was collected using a flexible tape made to coincide with the tool used for measuring the child seat tether hardware. The tether distance measurement tool is shown in Figure 4. The tool was designed to be hooked onto the tether anchor and pulled taut to the back of the seat.

Figure 4. Tether distance measurement tool

Another part of the measurement process was to measure child restraint tether hardware; a similar measurement device was created to measure the hardware. A picture of the measurement device is shown in Figure 5. The tool accurately measured the tether anchor latch (hook) to the rearmost edge of the strap adjuster.

Figure 5. CRS tether hardware measurement tool

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3. Results

Table 1 contains a summary of the results from the vehicle survey. The results showed all the tether anchor positions surveyed were within the current FMVSS No. 225 zone. Nine of the 11 positions passed by being outside the UMTRI alternate 325-millimeter zone. Five of the 11 positions surveyed passed the NPRM-proposed tether distance by having a measurement greater than 165 millimeters. For every vehicle measured, there was sufficient space to relocate the tether anchor to meet the tether distance measurement or the 325-millimeter UMTRI alternate measurement, although redesign or reinforcement may be necessary because of unknown structural components in the space available. Also, the space needed behind the seat back to locate the tether anchor is usually smaller for the UMTRI alternate 325-millimeter zone than the proposed tether distance measurement for rear deck mounted tether anchors. Appendix A contains the plots for all the vehicles measured.

Table 1. Tether survey results

Vehicle			**Tether Location**				
Year	**Make**	**Model**	**RDP** Rear Driver Position	**RCP** Rear Center Position	**FMVSS No. 225 Zone** Pass/Fail	**Alternate 325-mm Zone (mm)** Greater than 325-mm measurement from R-point	**Tether Distance Measurement (mm)** Greater than 165 mm
2010 Ford Taurus			Rear Deck		P	384	149
				Rear Deck	P	436	141
2011 Cadillac CTS			Rear Deck		P	294	68
				*Rear Deck	P	409	74
2016 Toyota Sienna			Seat Back		P	742	757
				N/A	N/A	N/A	N/A
2011 Hyundai Sonata			Rear Deck		P	308	75
				*Rear Deck	P	365	65
2016 Chevrolet Tahoe			Seat Back		P	625	657
				Seat Back	P	628	637
2016 Nissan Rogue			Seat Back		P	433	469
				*Roof	P	630	460
* SAE-J826 3D manikin torso angle affected by seat shape or fold down center console							

The pickup truck vehicle owner's manual specified the use of tether routers to properly install the CRS. The results for the pickup truck can be found in Table 2. The figures in Appendix A for the pickup truck show the wrap-around distance measured using the tether distance measurement tool between the tether router and adjacent tether anchor. Evaluating the pickup truck via the same method as the other vehicles, the pickup truck passed the FMVSS No. 225 zone but did not pass the UMTRI alternate 325-millimeter zone. However, utilizing the routers allowed it to pass the NPRM-proposed tether distance measurement.

For the pickup truck, there was not sufficient space to relocate the tether anchor to meet the tether distance measurement without using routers.

Table 2. Pickup truck results

Vehicle			**Tether Location**				
Year	**Make**	**Model**	**RDP** Rear Driver Position	**RCP** Rear Center Position	**FMVSS No. 225 Zone** Pass/Fail	**Alternate 325-mm Zone (mm)** Greater than 325-mm measurement from R-point	**Tether Distance Measurement (mm)** Greater than 165 mm
2016 Chevrolet Silverado			*Rear Deck (Tether Router)		P	142	355
				*Rear Deck (Tether Router)	P	147	320
* SAE-J826 3D manikin torso angle affected by seat shape or fold down center console							

3.1 CRS Tether Hardware Survey

To gather information on CRSs and tether hardware, 20 CRSs were collected from various manufacturers. The measurements collected as part of the CRS survey were length of the tether strap to the locking belt clip, the total forward facing height of the seat, and the height at which the tether was mounted to the child seat shown in Figure 6.

Figure 6. Measurements collected from CRS (seat height and tether attachment height)

All the CRS measurements can be found in Appendix B. Out of the 20 child restraints that were surveyed, the Graco Argo Elite had the longest tether strap at 190 millimeters compared to the NPRM maximum length of 165 millimeters. Sixteen of 20 tether hardware measured less than or equal to 165 millimeters in length, with a minimum length observed of 83 millimeters and a maximum length observed of 190 millimeters. These lengths were comparable to those found at UMTRI.

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4. Discussion

While conducting the survey, it was difficult to use the SAE-J826 3D manikin in the second row of the vehicle, especially in the center position. Seats with built-in fold down cup holders created an issue when trying to achieve the proper H-point position as it would not allow the 3D manikin to rest fully against the seat back. Another issue was that the legs could not always be installed due to interference with the front seat tracks or center transmission housing. Both issues are depicted in Figure 7. During this study, if the 3D manikin could not be installed properly in the center seating position, the legs were not utilized and the rest of the SAE-J826 procedure was followed as specified.

Figure 7. SAE-J826 3D manikin installation issues

There were also challenges when trying to define the SB point at the location defined in the NPRM "at the intersection of the plane parallel to the torso line reference plane that passes through the rearmost point of the seat and wrap-around line from the V-point to tether anchorage." The wrap-around distance and the intersection with the rearmost point on the seat could not be measured with the coordinate measurement machine, therefore the SB point had to be simplified to the rearmost part of the seat or the head restraint at the center of the seating position. Additionally, some comments to the NPRM pointed out that the SB point cannot be defined in some vehicle geometries because the wrap-around distance from V-point to tether anchor never intersects the rearmost point on the seat.

Another observation, for the pickup truck and the center position in the Nissan Rogue, was that the tether anchors are not always in-line with the centerline of the seat. In that case, the tether distance measurement was off-axis and would not match measurements in a pure two-dimensional environment. It was challenging to compare the off-centered tether anchors to the UMTRI alternate 325-millimeter zone, which is plotted and evaluated in two dimensions. If the UMTRI alternate zone was three-dimensional, as shown in Figure 8 for the pickup truck rear center position, the plot indicates that using the adjacent tether anchor as specified in the vehicle owner's manual would pass the UMTRI alternate 325-millimeter zone. In Figure 8, the rearmost

point on the seat is shown in black, the tether router in the seating position is shown in light blue, and the adjacent seating position tether anchor (router) is shown in red.

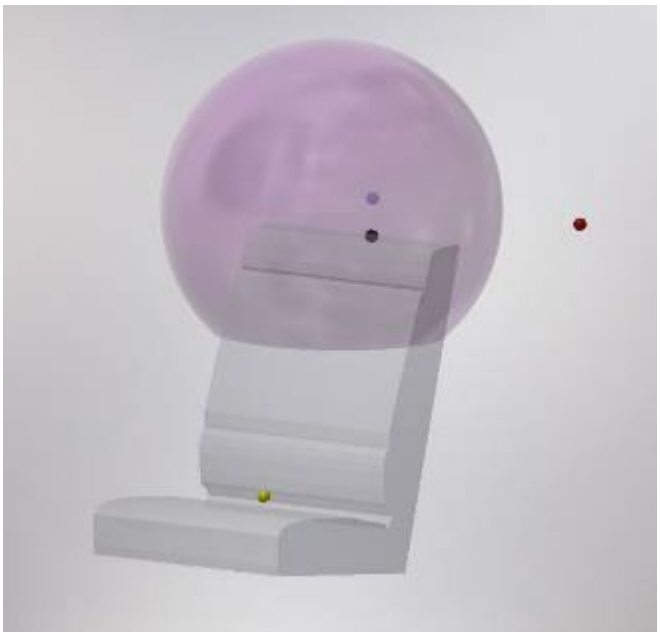

Figure 8. Three-dimensional UMTRI Alternate Zone example

After completing the survey, VRTC completed CRS installations to verify that a vehicle with a 165-millimeter tether distance measurement would allow proper installation of a CRS with a tether length of 165 millimeters. The child seat selected was an Evenflo Triumph with a tether length of 164 millimeters. Two vehicles were selected, a 2010 Ford Taurus (RDP) with a 149-millimeter tether distance measurement (the closest to 165 mm) and the 2011 Cadillac CTS (RCP), which had an odd seat shape and one of the smaller tether distance measurements (74 mm) as shown in Figure 9. Both the 2010 Ford Taurus (RDP) and 2011 Cadillac CTS (RCP) positions passed the UMTRI alternate 325-millimeter zone.

Figure 9. Taurus (left) and CTS (right) with Evenflo Triumph tether installed

Two experienced users were selected to install the CRS into the two vehicles selected. Because the 2010 Ford Taurus (RDP) had a tether distance measurement less than 165 millimeters, it was expected that tightening the tether would be difficult. However, the vehicle owner's manual included instructions to install the CRS using tether attachment by routing it under the head restraint. Because the head restraint was adjustable, there were no difficulties tightening the tether. Thus, the tether distance measurement, defined as the distance from the tether anchor to

the rearmost point on the seat (SB point), does not account for the ease of installation when the head restraint is raised or removed for CRS installation.

It was expected that the tether would be difficult to tighten for the 2011 Cadillac CTS (RCP), since it had a tether distance measurement of 74 millimeters. However, installation was not difficult because there was no head restraint. The seat back cushion in the Cadillac was thick which allowed enough space between the tether anchor and the CRS for the hardware to be tightened. However, there may not have been space to tighten the tether if a CRS with longer tether hardware had been used. It was observed that for the 2011 Cadillac CTS (RDP), the vehicle owner's manual specified for the CRS tether attachment to be routed over the fixed head restraint which caused no difficulties with tightening the tether attachment. If a vehicle with similar spacing had an adjustable head restraint and specified routing under the head restraint in the vehicle owner's manual, it would have been difficult to tighten the tether attachment because the tether attachment hardware would be underneath the head restraint. This indicates that ease of installation can be improved with vehicle owner's manual instructions and not just measurement requirements.

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5. Summary

A survey of measurements comparing the current FMVSS No. 225 zone, the NPRM-proposed tether distance measurement, and the UMTRI alternate 325-millimeter zone was completed. The results showed all the tether anchor positions surveyed were within the current FMVSS No. 225 zone. Nine of the 11 positions passed by being outside the UMTRI alternate 325-millimeter zone. Five of the 11 positions surveyed passed the NPRM-proposed tether distance measurement by having a measurement greater than 165 millimeters. For every vehicle measured, excluding the pickup truck, there was sufficient space to relocate the tether anchor to meet the proposed tether distance measurement requirement, although it may be necessary to redesign or reinforce the tether anchor because of unknown structural components in the space available. Also, the space needed behind the seat back to locate the tether anchor is usually smaller for the UMTRI alternate 325-millimeter zone than the proposed tether distance measurement for rear deck mounted tether anchors. A survey of CRSs showed that 16 of 20 tether anchor hardware measured less than or equal to 165 millimeters in length. CRS installation in two different vehicles with tether anchors that met the UMTRI alternate 325-millimeter zone allowed proper installation of a CRS with a tether hardware length of 165 millimeters. However, vehicle seating positions with tether anchor locations that do not meet the proposed tether distance measurement requirement also allowed proper installation of the CRS. Nevertheless, it was observed that ease of installation can be improved with vehicle owner's instructions and not just measurement requirements.

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80 FR 3744, (Docket submission. Docket No. Docket No. NHTSA-2014-0123-0001 in Regulations.gov). January 2015. www.regulations.gov/document?D=NHTSA-2014-0123-0001

Federal Register of Legislation [Australia]. (2012). *Vehicle standard (Australian Design Rule 34/02 – Child restraint anchorages and child restraint anchor fittings*) www.legislation.gov.au/Details/F2019C00040

Klinich, K. D., Boyle, K., Orton, N. R., Manary, M. A., & Ebert, S. (2016, January). *Investigation of clearance criterion between tether anchor and head restraint* (Report No. UMTRI-2016-4). University of Michigan Transportation Research Institute.

SAE International. (2015, November 10). [Standard No.] *J826_201511, Devices for use in defining and measuring vehicle seating accommodation*. www.sae.org/standards/content/j826_201511/

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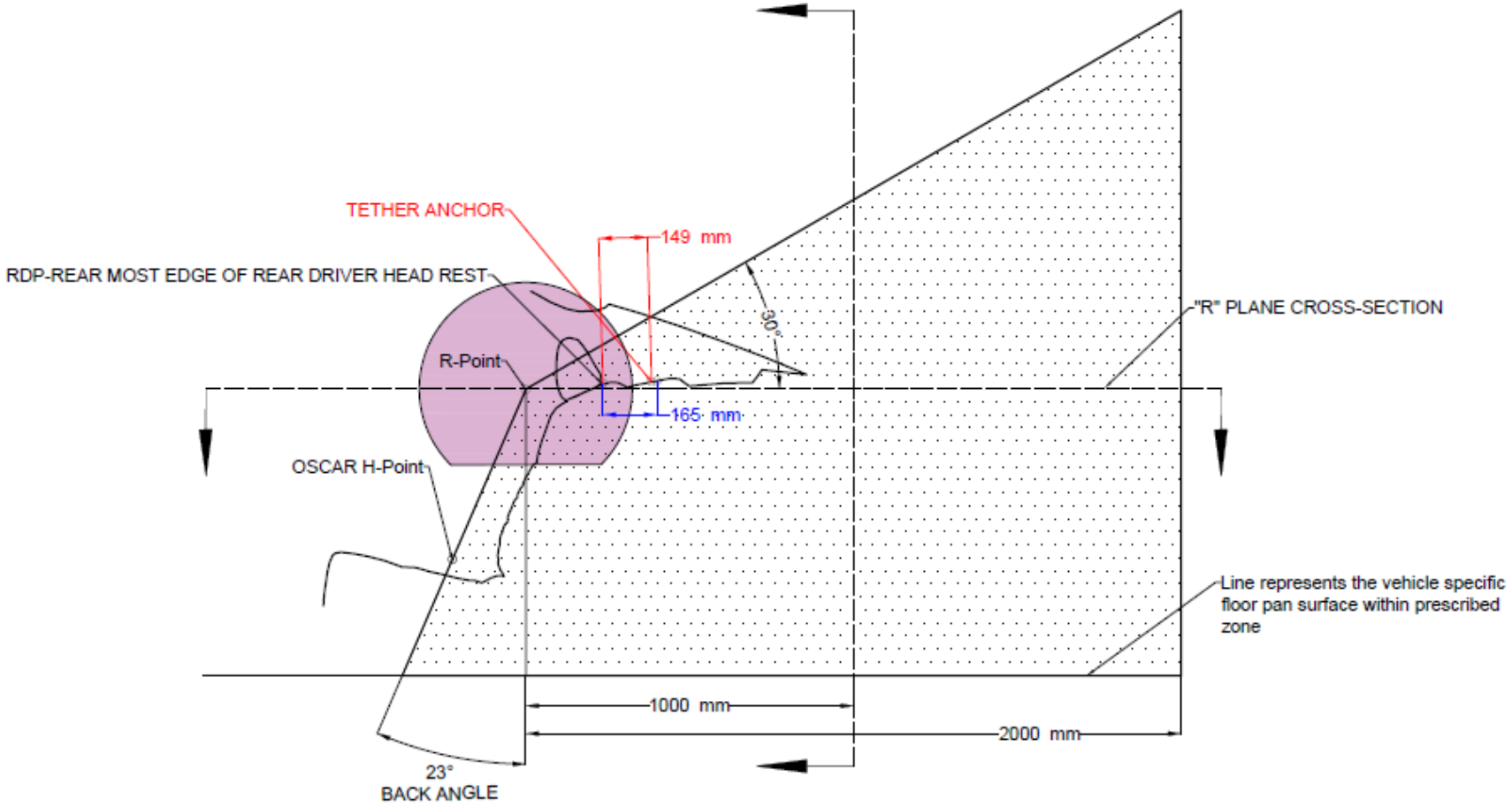
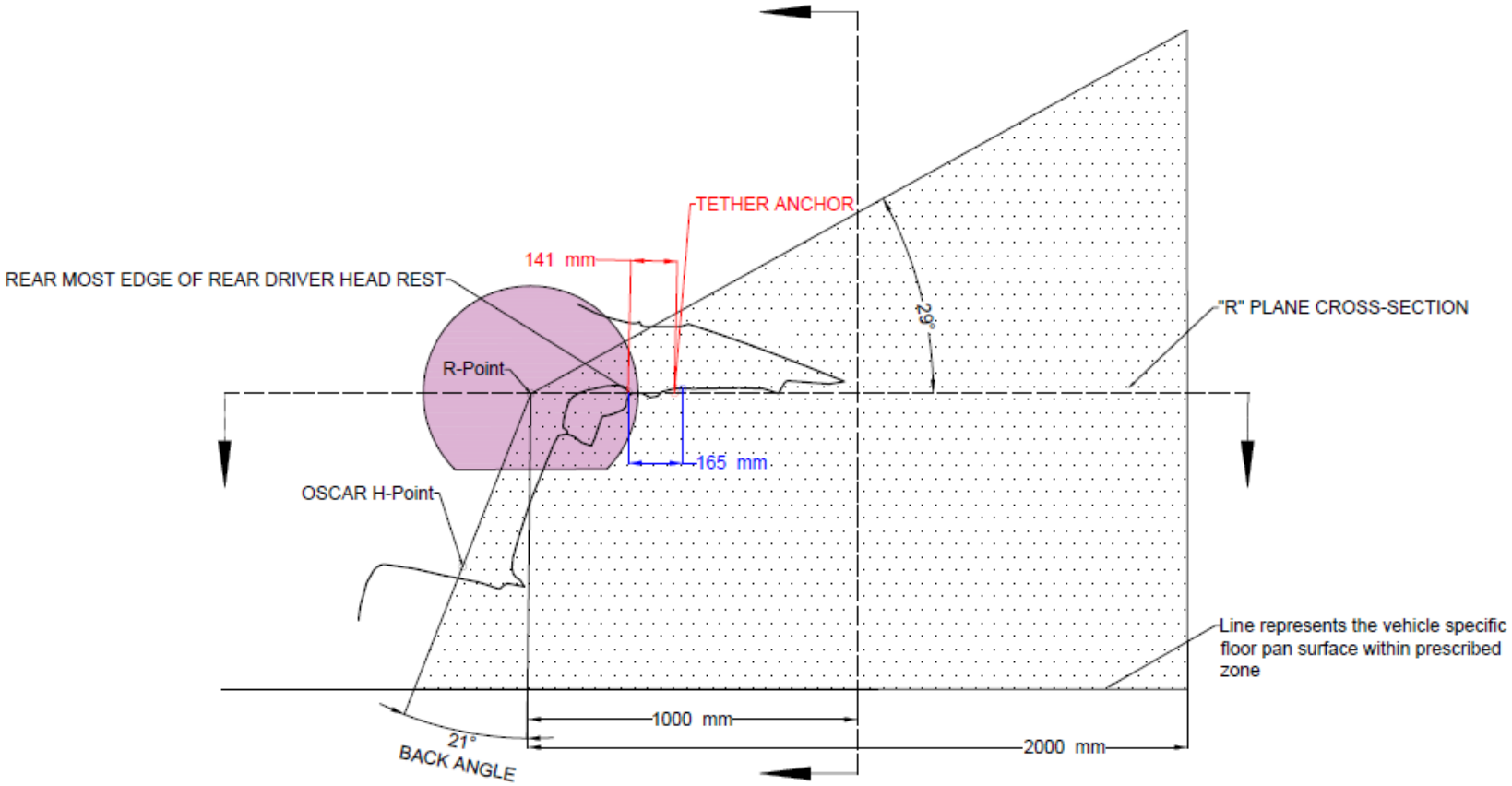
Appendix A. Results

2010 Ford Taurus

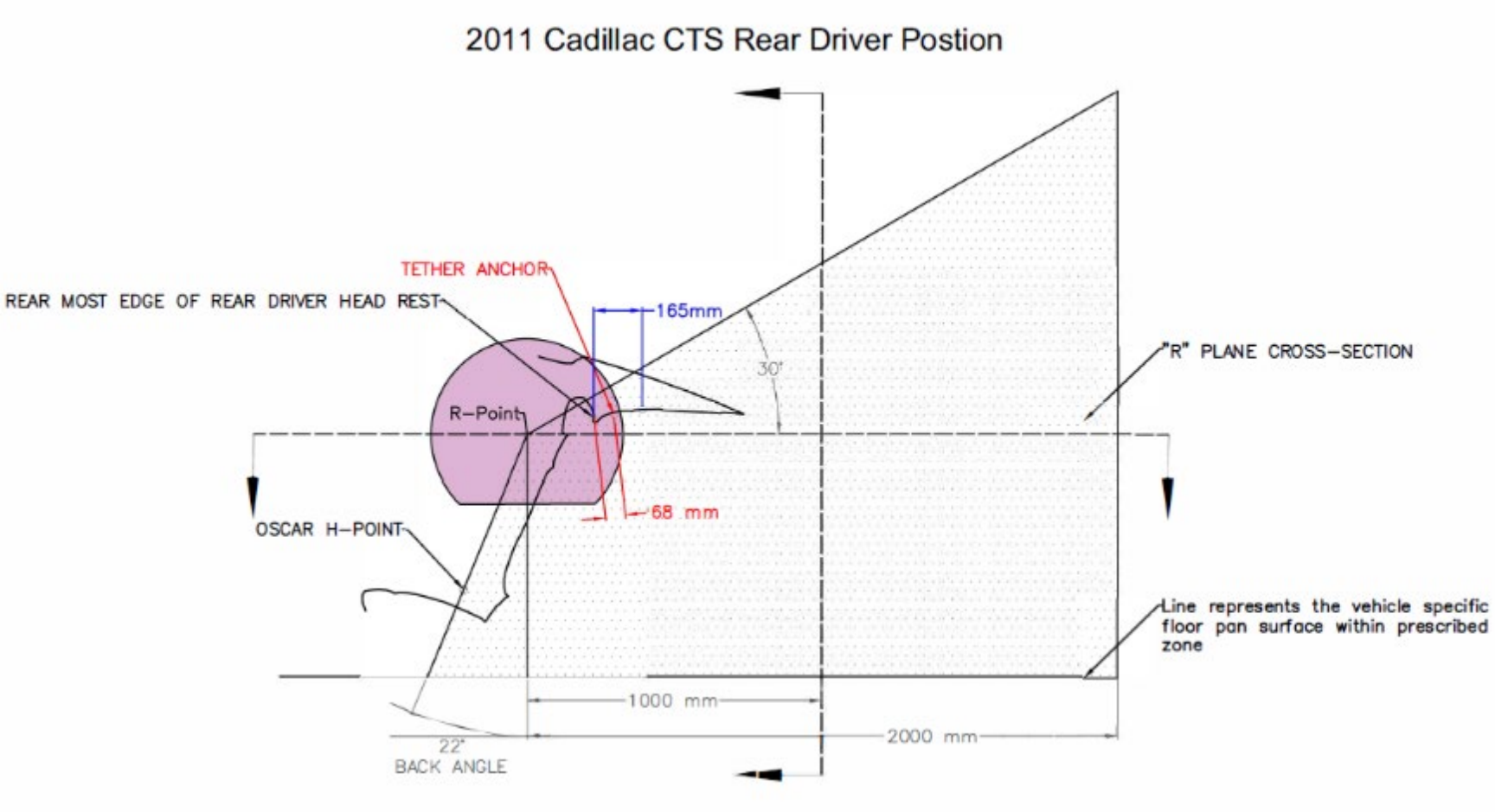
2010 Ford Taurus Rear Driver Position



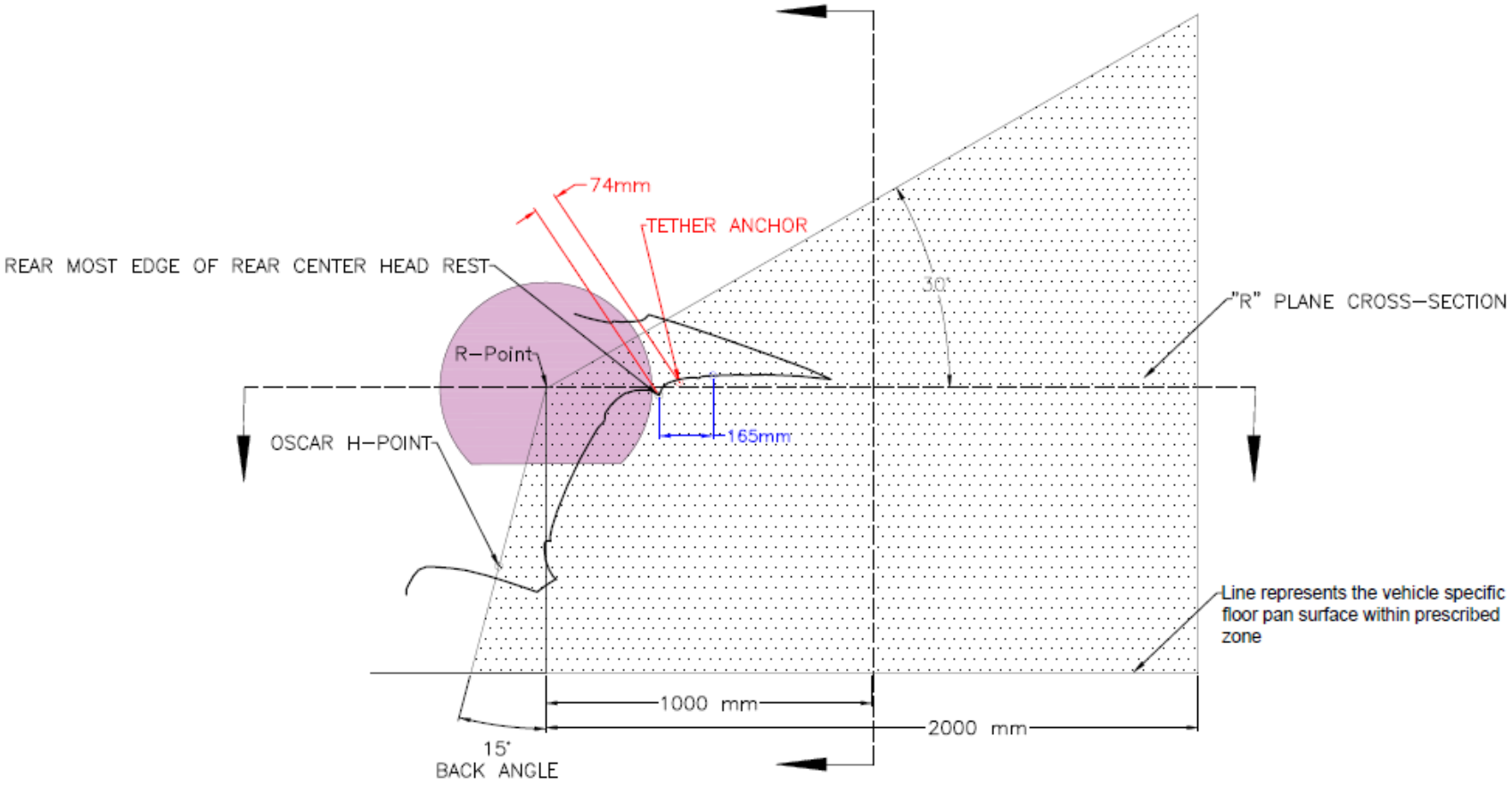
2010 Ford Taurus Rear Center Position



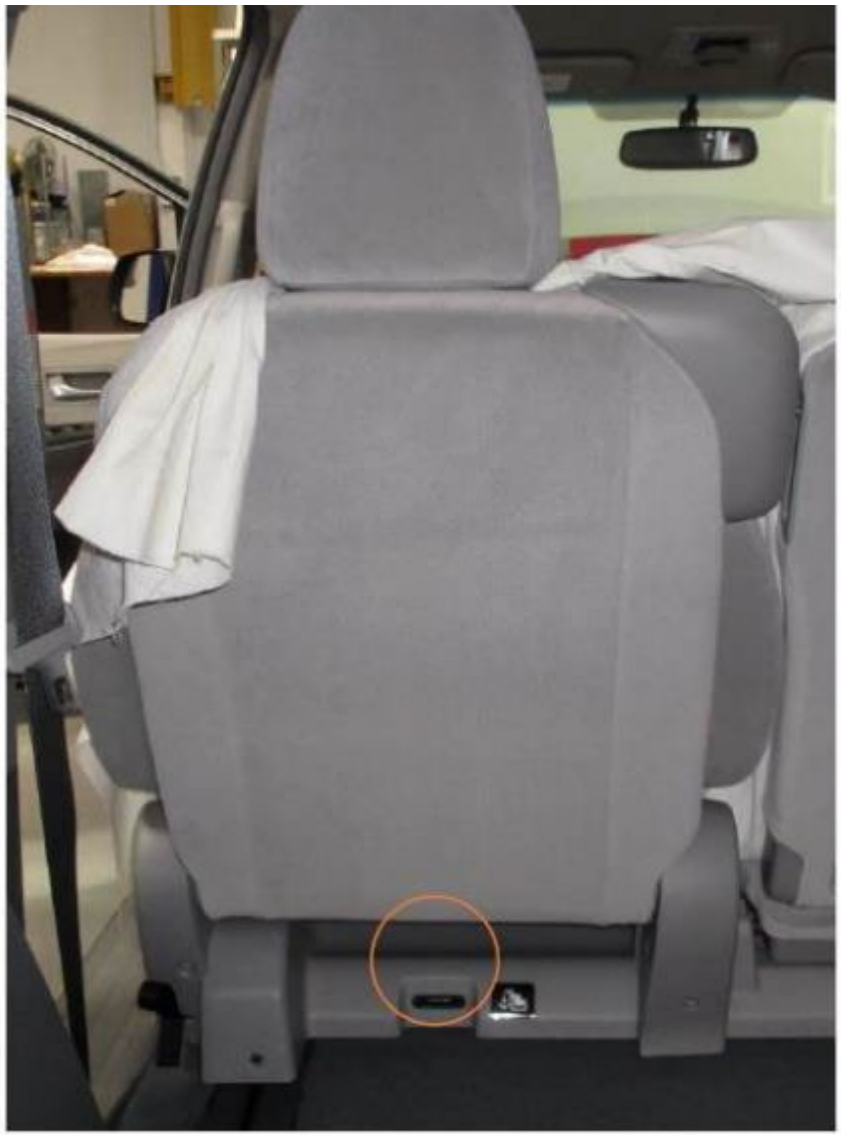
2011 Cadillac CTS

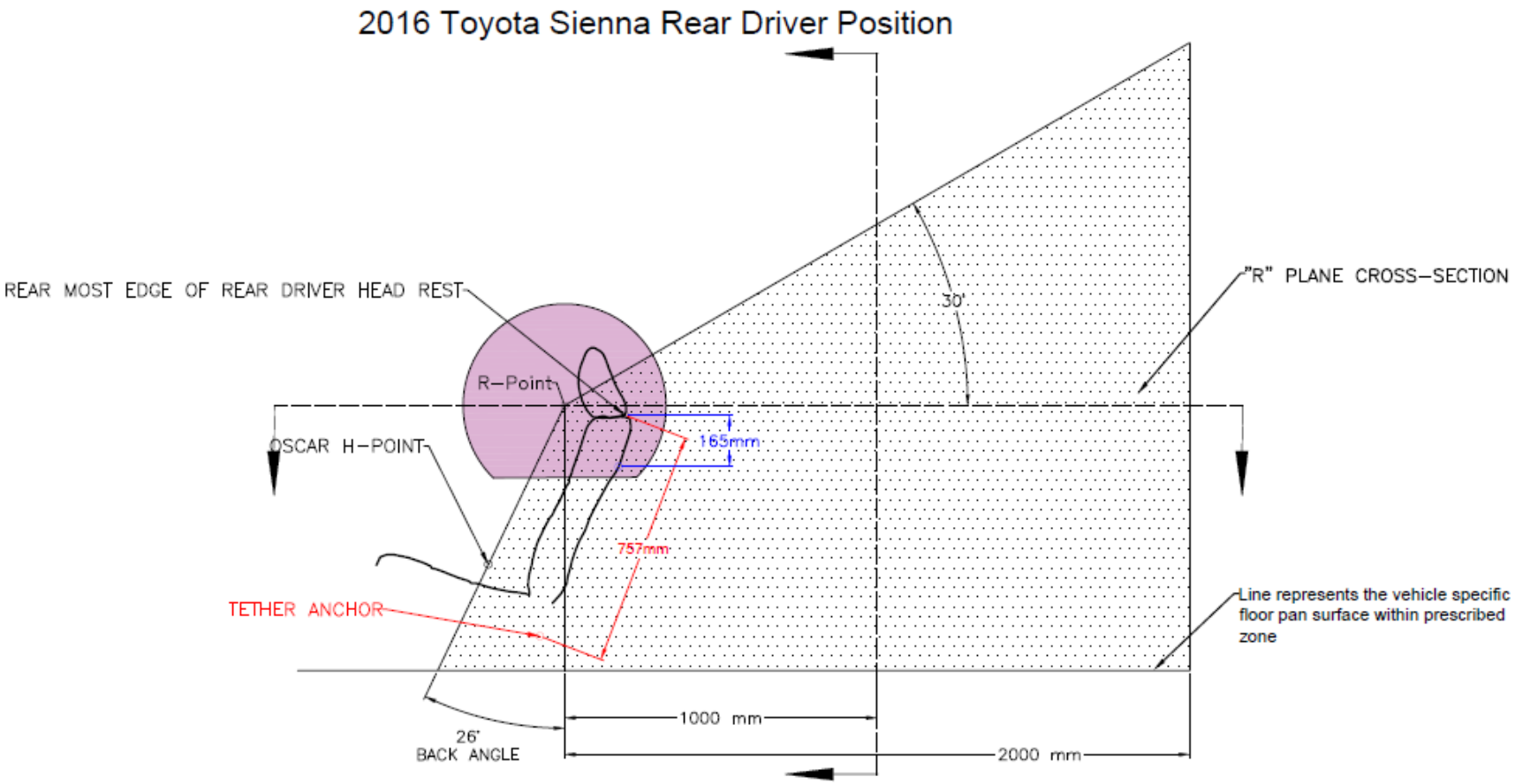

2011 Cadillac CTS Rear Driver Postion
TETHER ANCHOR
REAR MOST EDGE OF REAR DRIVER HEAD REST
165mm
30°
"R" PLANE CROSS-SECTION
R-Point
68 mm
OSCAR H-POINT
Line represents the vehicle specific floor pan surface within prescribed zone
1000 mm
2000 mm
22°
BACK ANGLE

2011 Cadillac CTS Rear Center Postion



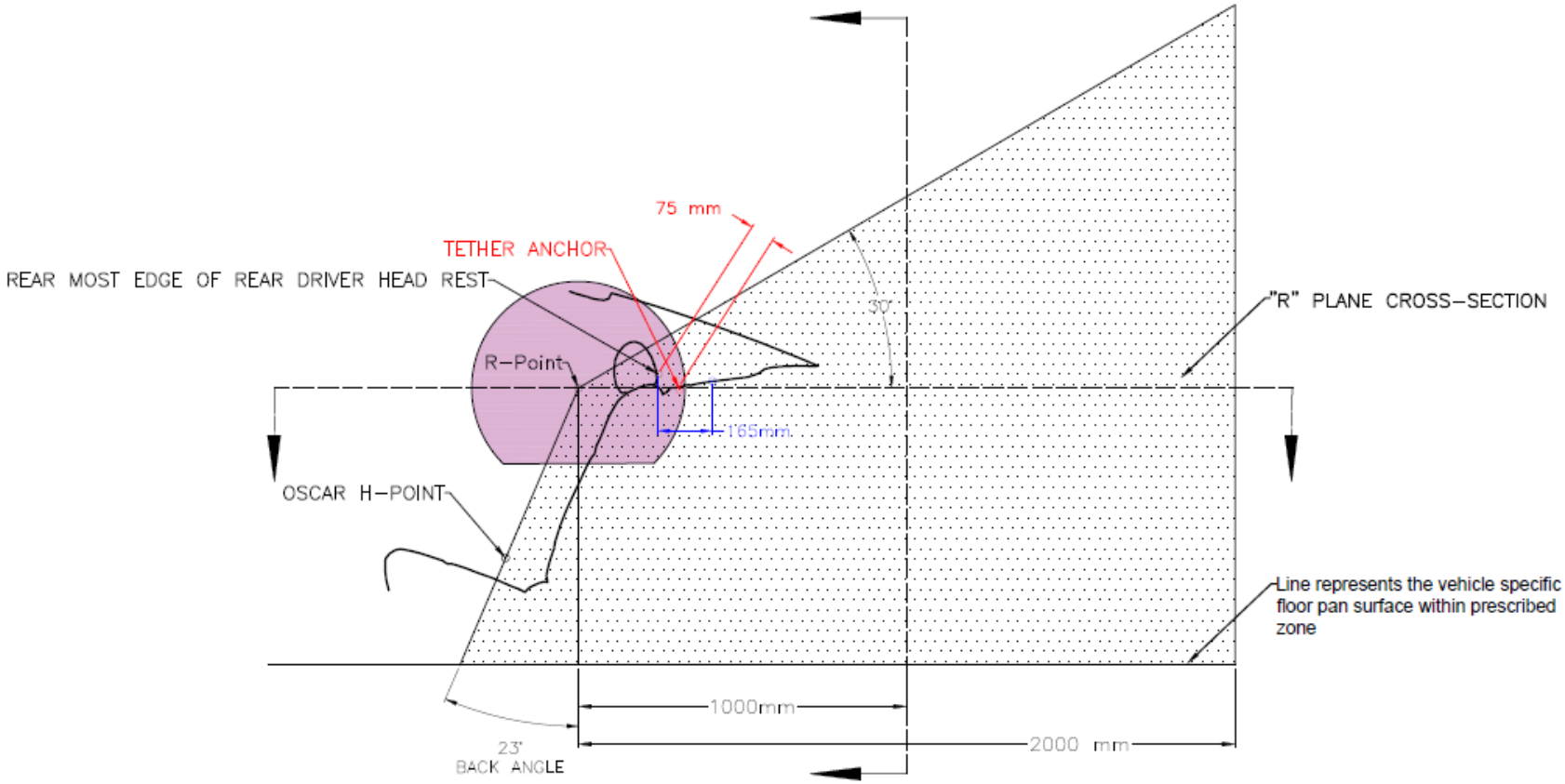
2016 Toyota Sienna

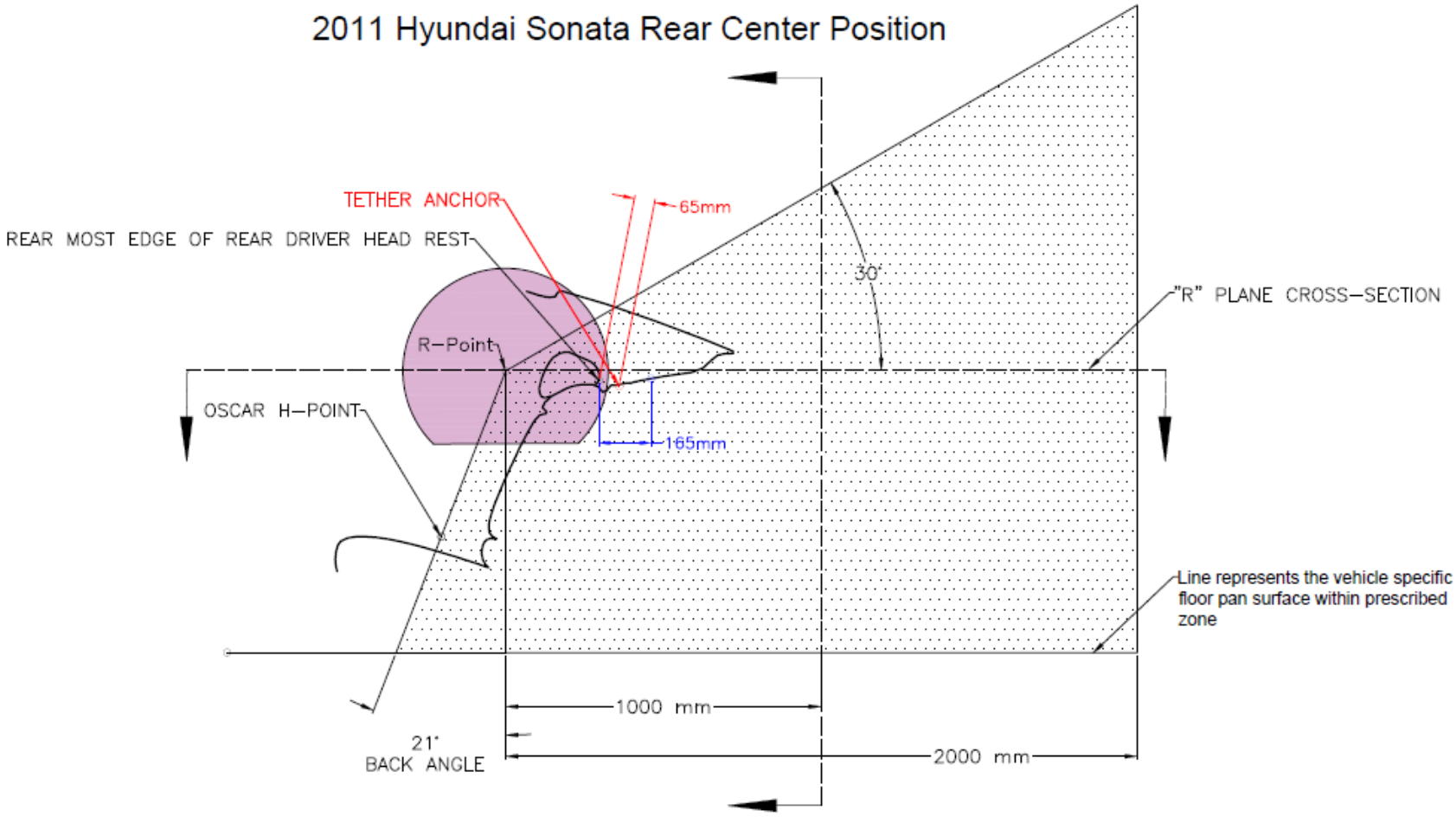



2016 Toyota Sienna Rear Driver Position
REAR MOST EDGE OF REAR DRIVER HEAD REST
R-Point
OSCAR H-POINT
165mm
757mm
TETHER ANCHOR
30°
"R" PLANE CROSS-SECTION
Line represents the vehicle specific floor pan surface within prescribed zone
1000 mm
2000 mm
26°
BACK ANGLE

2016 Hyundai Sonata

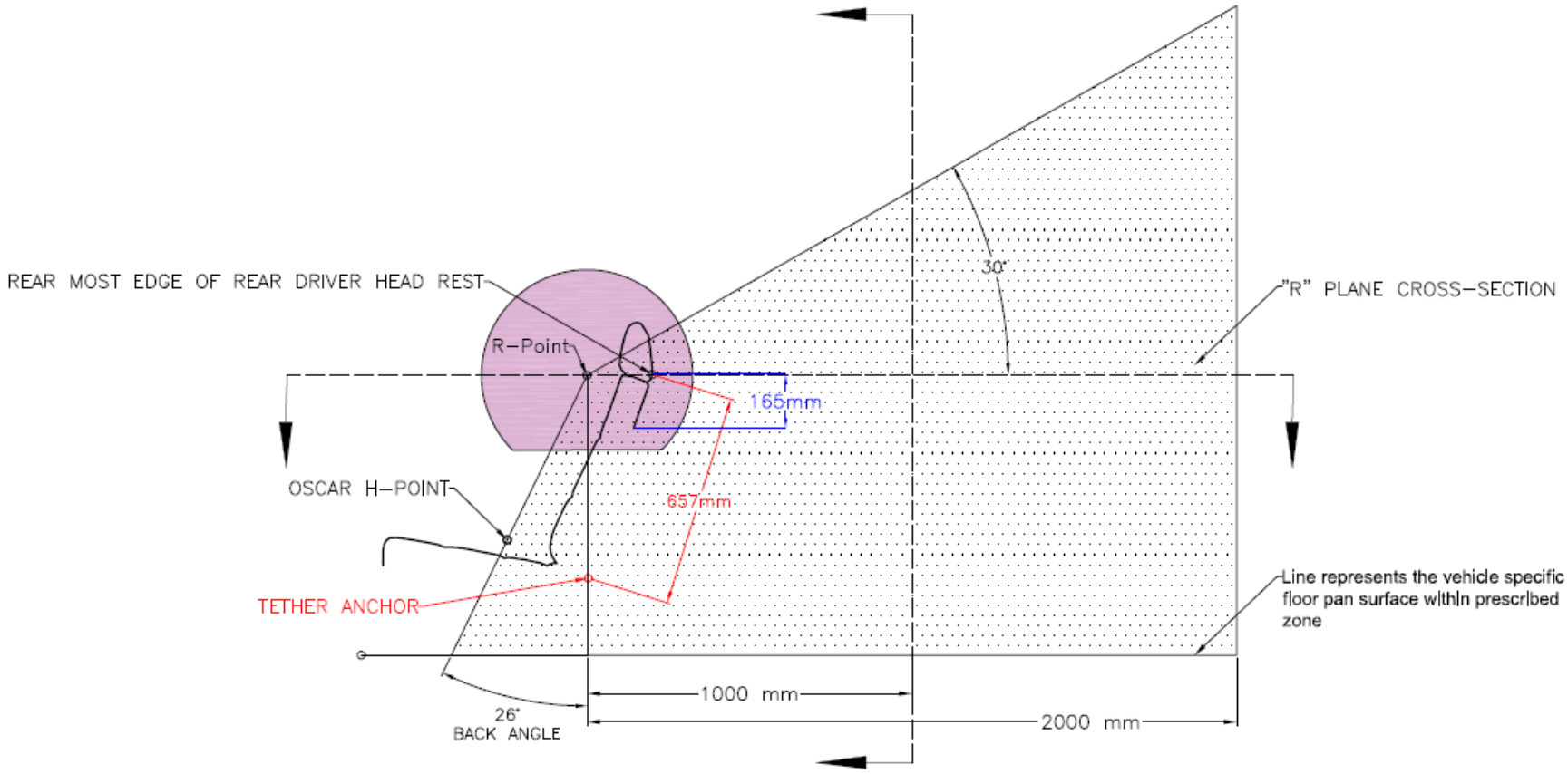
2011 Hyundai Sonata Rear Driver Position



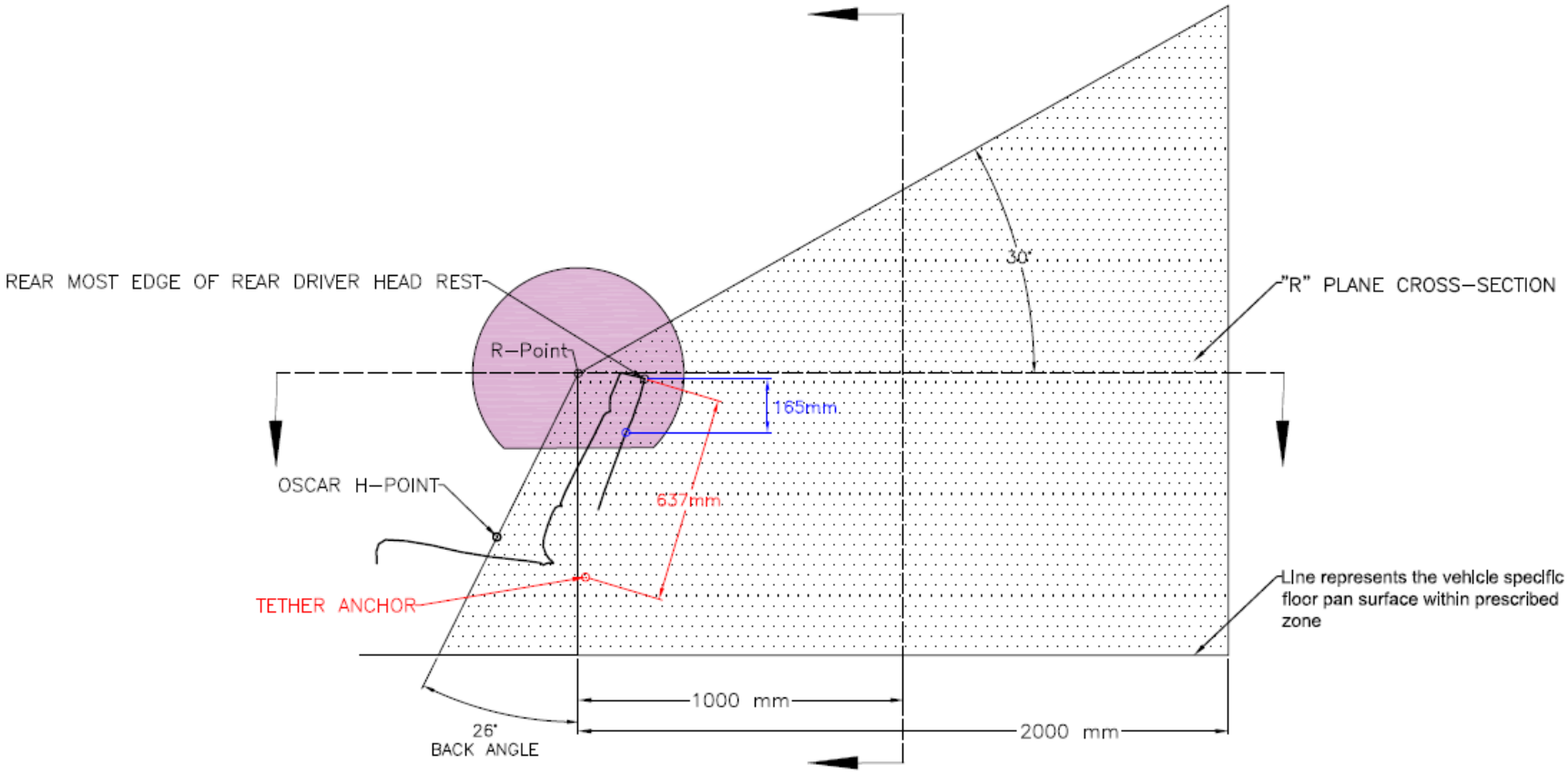

2011 Hyundai Sonata Rear Center Position
TETHER ANCHOR
65mm
REAR MOST EDGE OF REAR DRIVER HEAD REST
30°
"R" PLANE CROSS-SECTION
R-Point
OSCAR H-POINT
165mm
Line represents the vehicle specific floor pan surface within prescribed zone
1000 mm
21°
BACK ANGLE
2000 mm

2016 Chevrolet Tahoe

2016 Chevrolet Tahoe Rear Driver Position

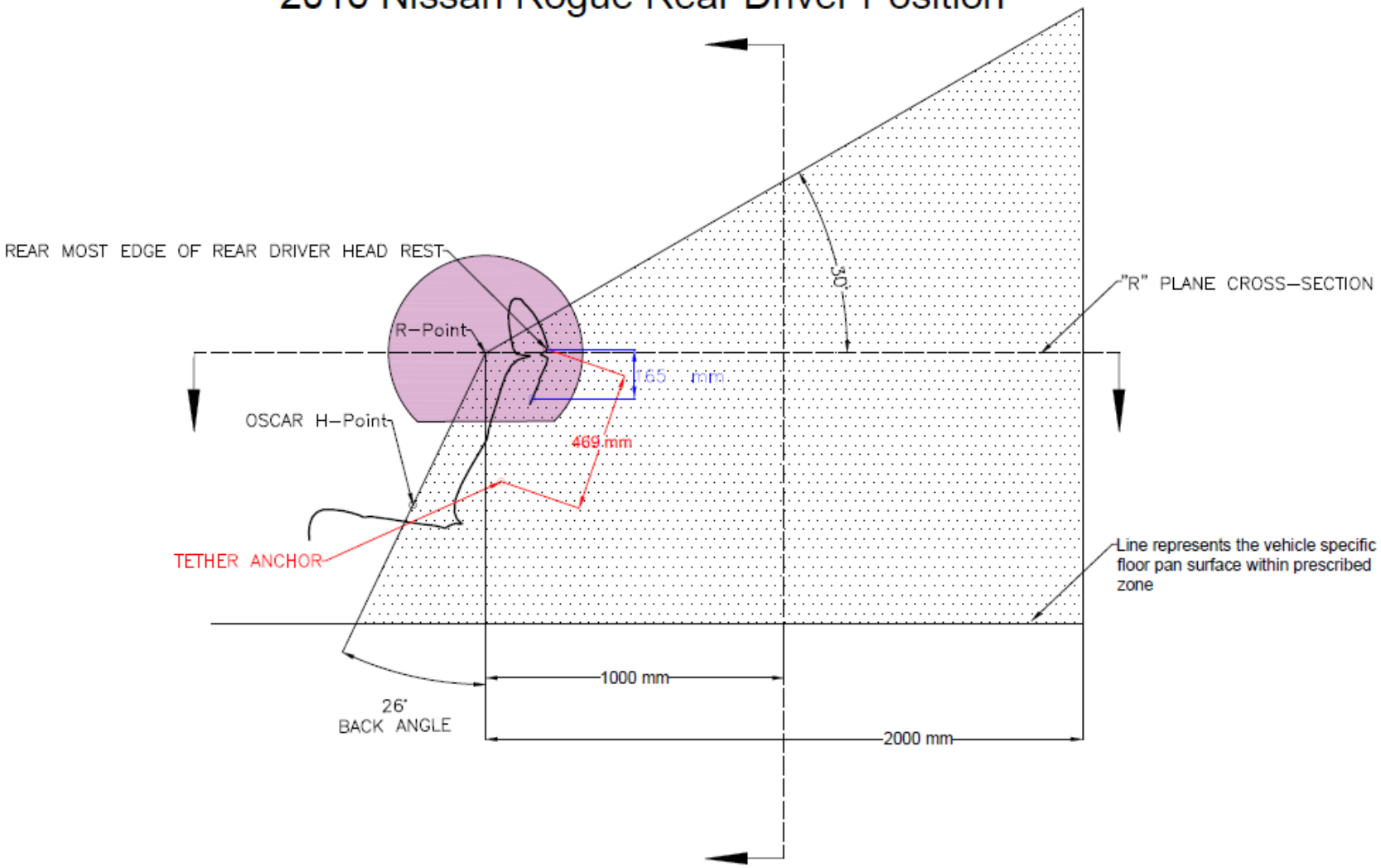


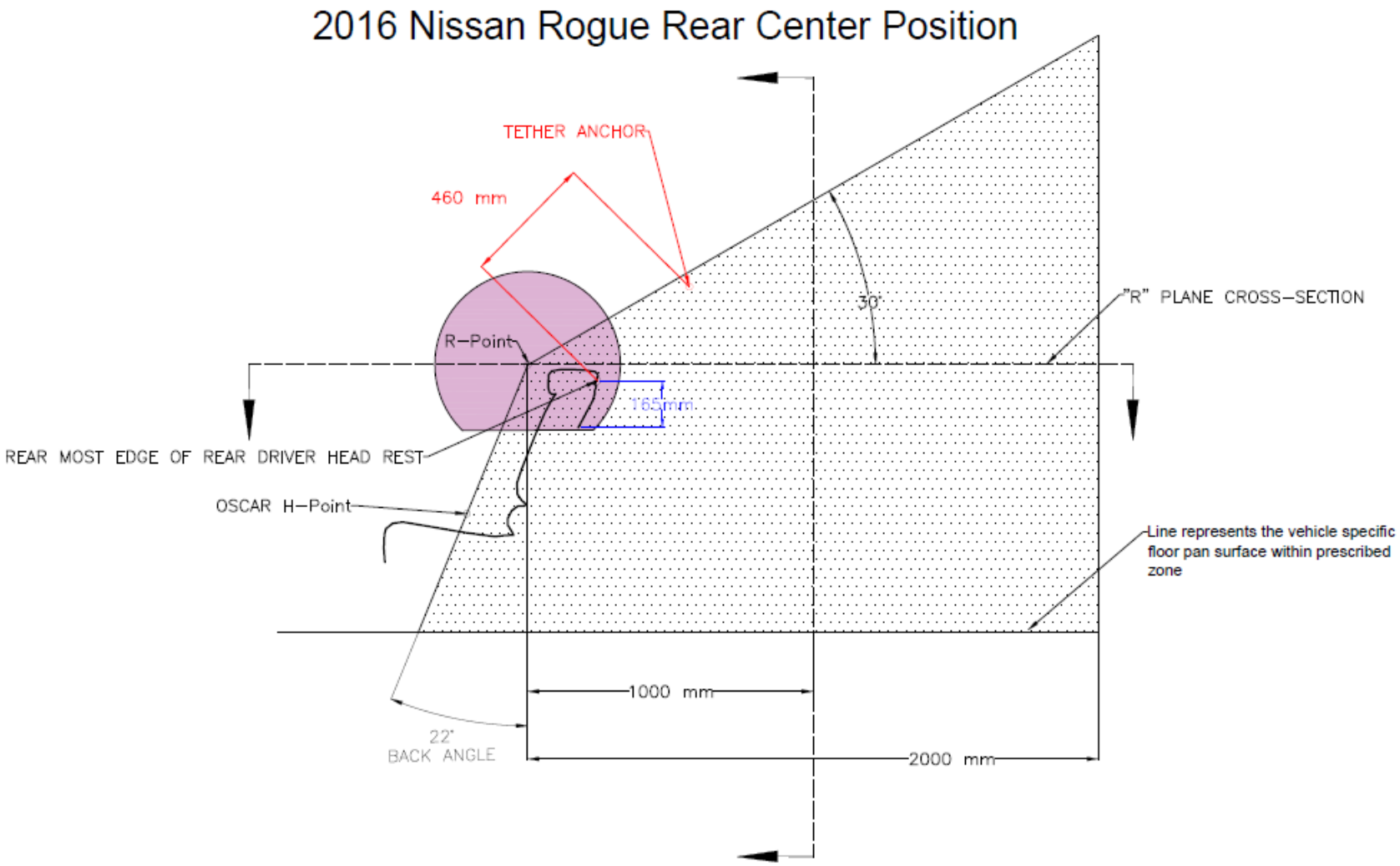
2016 Chevrolet Tahoe Rear Center Position



2016 Nissan Rogue

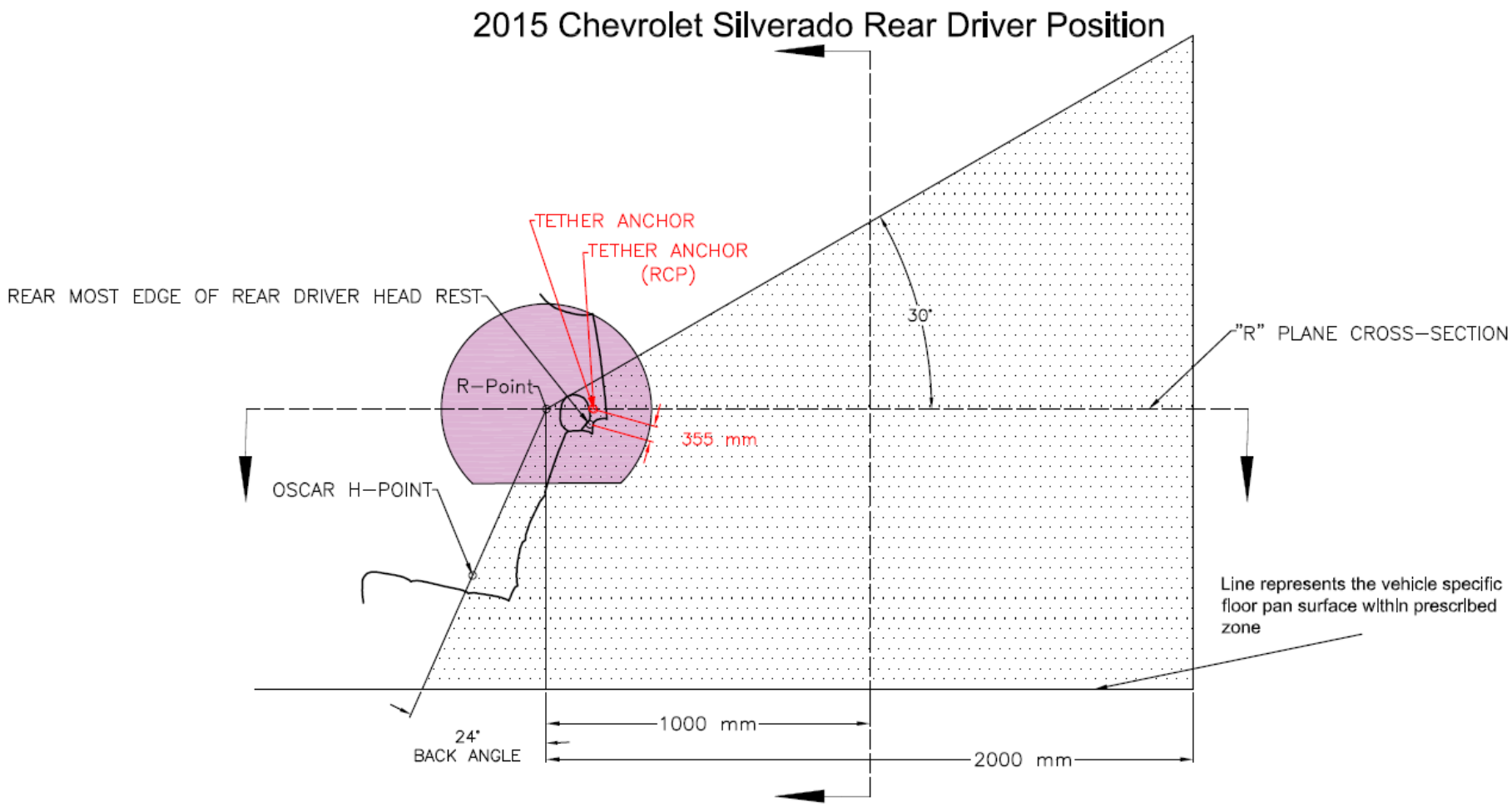
2016 Nissan Rogue Rear Driver Position



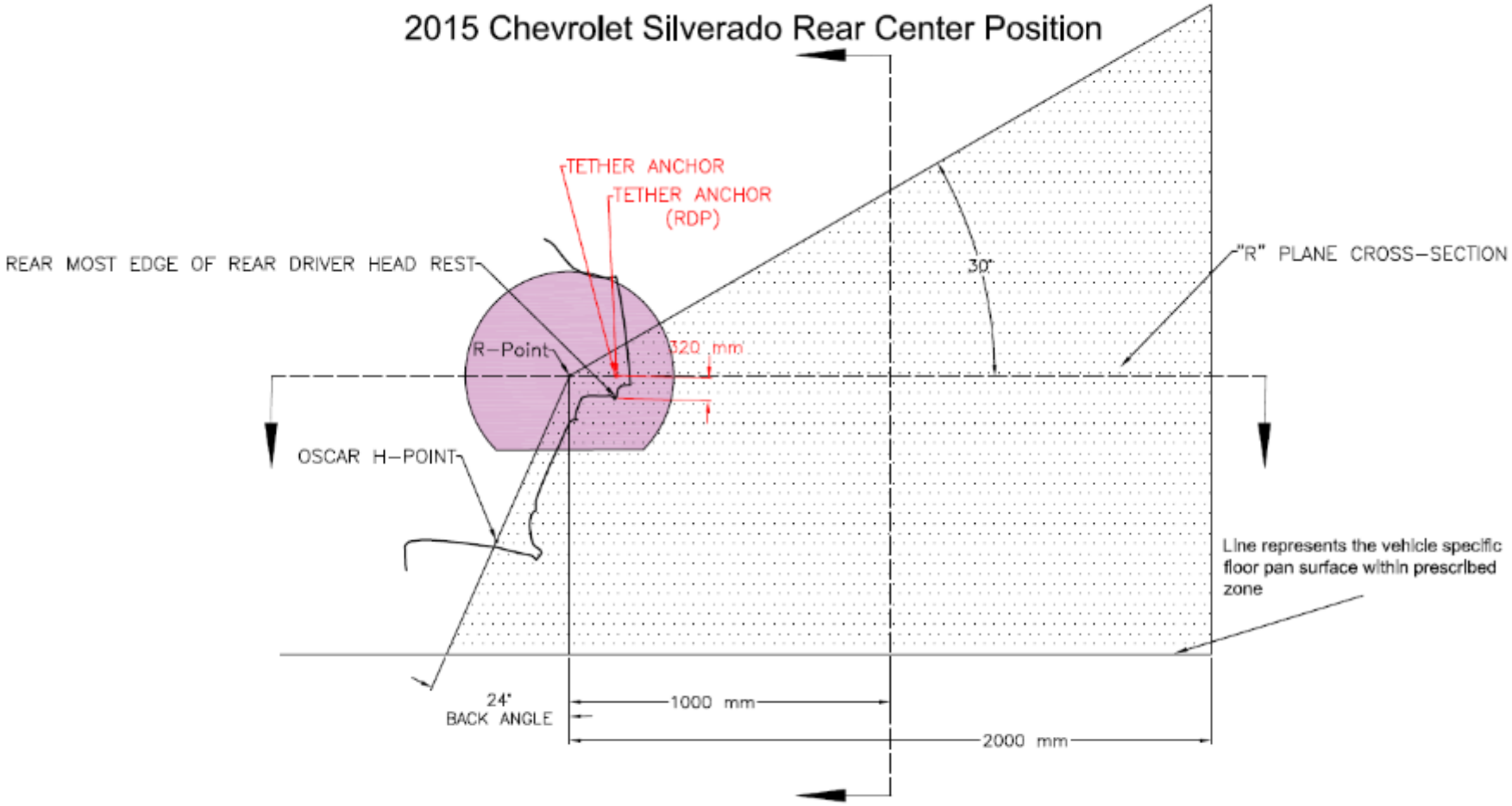


Note: The plot shows the tether distance measurement (in red) using the tether distance measurement tool to the RCP tether anchor, which is not in the centerline of the seat, as reported in Table 2.

2015 Chevrolet Silverado



Note: The plot shows the tether distance measurement (in red) using the tether distance measurement tool to collect the wrap-around distance between the RDP tether anchor (router) and the RCP tether anchor as reported in Table 2.



Note: The plot shows the tether distance measurement (in red) using the tether distance measurement tool to collect the wrap-around distance between the RCP tether anchor (router) and the RDP tether anchor as reported in Table 2.

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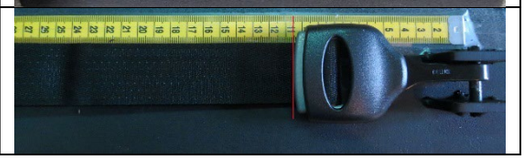
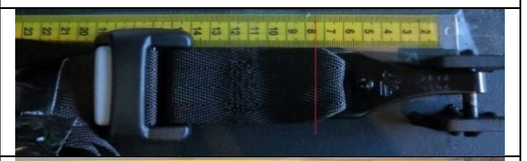
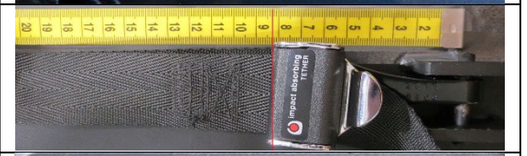
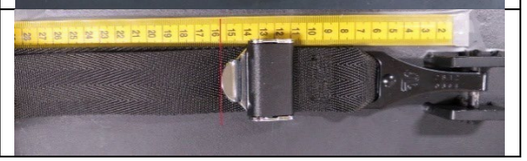
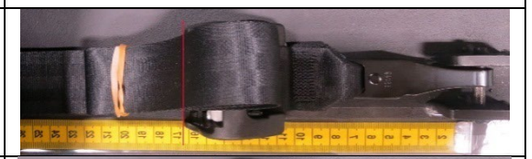
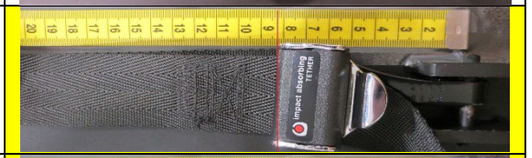
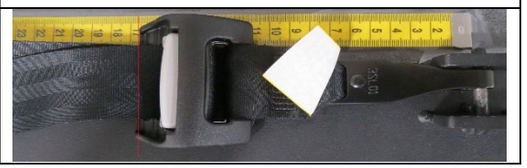
Appendix B. CRS Tether Hardware Survey Results

Make	Model	Model #	Length (mm)	Overall Seat Height (mm) (Highest Position)	Overall Seat Height (mm) (Lowest Position)	Tether mounting height (mm)	Image
Evenflo	Maestro	3102198	148	679		570	
Evenflo	Triumph	3801819	164	700		620	
Graco	Nautilus	8J00MTX JJ	185	845		565	
Graco	Comfort Sport	1794333 JJ	145	690		610	
Kiddy World Plus	Rumba	079 Rumba	115	822		718	
Clek	Foonf	10	105	800	690	660	

Make	Model	Model #	Length (mm)	Overall Seat Height (mm) (Highest Position)	Overall Seat Height (mm) (Lowest Position)	Tether mounting height (mm)	Image
Graco	Argos Elite	1896354	190	880	690	560	
Britax	Boulevard	E9LX615	83	800	660	570	
Graco	Size 4 Me 65	1903756	180	825	620	550	
Evenflo	Tribute	3811985	163	630		600	
Maxi Cosi	Pria 70	CC099-CKN	148	650		625	
Combi	Coccoro	8220	154	650		625	

Make	Model	Model #	Length (mm)	Overall Seat Height (mm) (Highest Position)	Overall Seat Height (mm) (Lowest Position)	Tether mounting height (mm)	Image
Evenflo	Chase LX	30611847	163	755		645	
Evenflo	Triumph	38231167	165	730		660	
Cosco	Scenera Next	CC123-CVA	148	560		540	
Britax	Marathon	E9LX11A	83	800	665	570	
Britax	Advocate	E9BB9P8	83	645		550	
Cosco	APT 40	CC117-CJZ	150	585		585	
Safety 1st	Complete Air 65	CC110-CJZ	150	750	685	490	

Make	Model	Model #	Length (mm)	Overall Seat Height (mm) (Highest Position)	Overall Seat Height (mm) (Lowest Position)	Tether mounting height (mm)	Image
Baby Trend	PROtect Premier Convertible	CV88A33A	166	560		543	

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Appendix C. Measurement Procedure

- Select vehicle to be measured.
- Document vehicle make, model, year, and how many tether positions are available.
- Position the vehicle on a flat surface with sufficient room to work with the doors open:
    - With the vehicle in place and the emergency brake engaged, measure the vehicle's attitude at the center of each fender just above the wheel;
    - Install jacks under the vehicle to avoid vehicle movement while collecting measurements;
        - If the jacks cause the vehicle's attitude to change, adjust equally at each fender.
- Align the coordinate measurement machine with the vehicle rear striker, setting the striker as the origin (0,0,0) and the X-axis as the centerline of the vehicle.
- Conduct an H-point drop in the position at which the tether is to be measured.
    - Seat the SAE J-826 3D manikin using the SAE J-826 procedure in the position being measured.
        - Using the coordinate measurement machine, measure the inboard and outboard H-point of the 3D manikin.
        - Create a mid-point from the inboard and outboard H-point.
        - Measure a point at the top of the manikin's torso pole.
- Document the location of the tether being measured.
    - Collect a point at the center of the tether anchor bar.
    - Collect a profile of the vehicle seat, head rest, and rear deck at the center of each top tether position.
    - Export the points to Microsoft Excel.
- Using the tether distance measurement tool (flexible anchor tape measure), collect the tether distance measurement by attaching the tool to the anchor and pulling the flexible tape toward the seat.
    - If there is a head restraint, the flexible tape should be pulled over or under the head restraint per the vehicle owner's manual.
    - The measurement is collected at the rearmost point of the head restraint;
        - If there is no head restraint, the measurement is to be collected at the rear edge of the seat back cushion.
- Take photos of each position measured.
- Using a piece of electrical tape, mark the location at 165 mm rearward of the rearmost point of the head restraint and document with pictures to show if space is available to relocate tether anchor.
- Once all the measurements have been collected, import the points into AutoCAD and create plots with the three different measurements/zones.
- Using visual inspection (FMVSS No. 225 zone), AutoCAD measurements (alternate 325-millimeter zone), and tool measurements (tether distance measurement), record the measurement results into the summary sheet table.

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**National Highway
Traffic Safety
Administration**

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